Atmospheric Option Value of Carbon Mitigation

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Outline

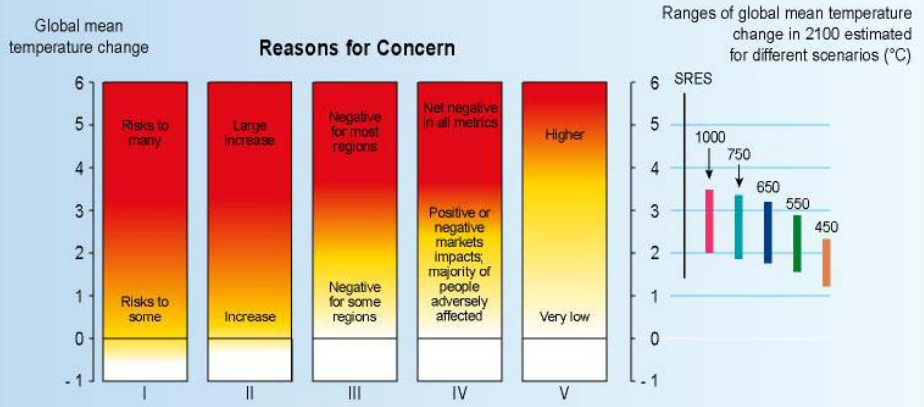
- Review of FCCC goals
- Simple tools: what carbon cycle models tell us about the proximity of "dangerous anthropogenic interference" and how to avoid it
- The role of sequestration in carbon mitigation

1992 UNFCCC

- Article 2: Stabilize atmospheric GHGs at levels that avoid "dangerous anthropogenic interference" (DAI) with the climate system
- Article 3: "Policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost"
- Room for interpretation:
  - What is DAI?
  - How to harmonize the goals in Articles 2 and 3?

What is "dangerous"?

Risks of climate change damages would be reduced by stabilizing CO_2 concentrations



I. Unique and Threatened Systems

Extinction of species.
Loss of unique habitats, coastal wetlands.
Bleaching and death of coral.

II. Extreme Climate Events

Health, property, and environmental impacts from increased frequency and intensity of some climate extremes.

III. Distribution of Impacts

Cereal crop yield changes that vary from increases to decreases across regions but which are estimated to decrease in most tropical and subtropical regions.
Decrease in water availability in some water-stressed countries, increase in others.
Greater risks to health in developing countries than in developed countries.
Net market sector losses estimated for many developing countries; mixed effects estimated for developed countries up to a few degrees warming and negative effects for greater warming.

IV. Global Aggregate Impacts

Estimates of globally aggregated net market sector impacts are positive and negative up to a few degrees warming and negative for greater warming.
More people adversely affected than beneficially affected even for warming less than a few degrees.

V. Large Scale, High Impact Events

Significant slowing of thermohaline circulation possible by 2100.
Melting and collapse of ice sheets adding substantially to sea-level rise (very low likelihood before 2100; likelihood higher on multi-century time scale).

SYR

IPCC, 2001

Thresholds for Singular Events

Event	Threshold	Study
Coral bleaching	~1° C	Hoegh-Guldberg, 1999
THC collapse	~3° C	Stocker and Schmittner, 1997
WAIS disintegration	~2° C	Oppenheimer, 1998
GIS disintegration	~1° C ~3° C (local)	Hansen, 2004, 2005; Gregory et al., 2004

IPCC TAR projects equilibrium warming of 2.0-5.2° C for stabilization at 550 ppm

What policies are "cost-effective"?

Often, those that postpone mitigation because:

- Time constant of capital turnover is large
- Development of alternatives takes time
- Discount rate is significant, so present costs exceed future benefits

These consideration led to WRE trajectories and similar proposals (now a decade old)

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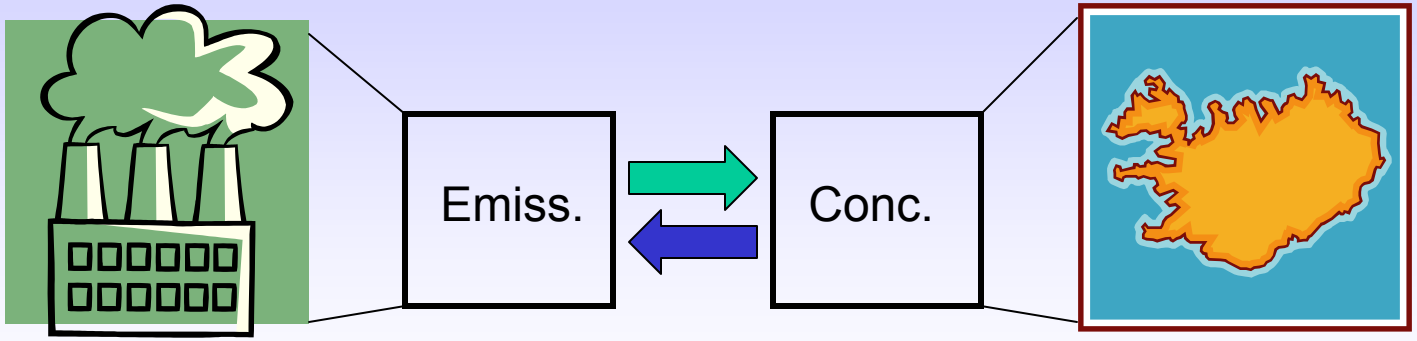
The Carbon Cycle as Mediator

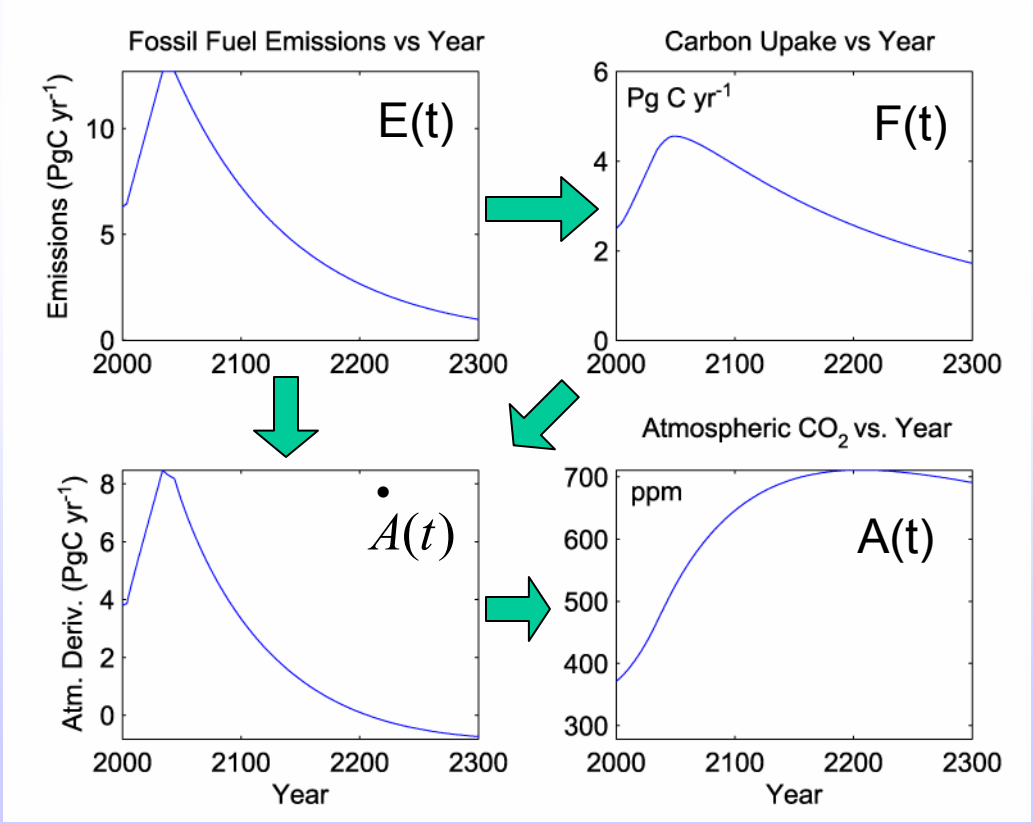


System governed by basic mass (carbon) balance:

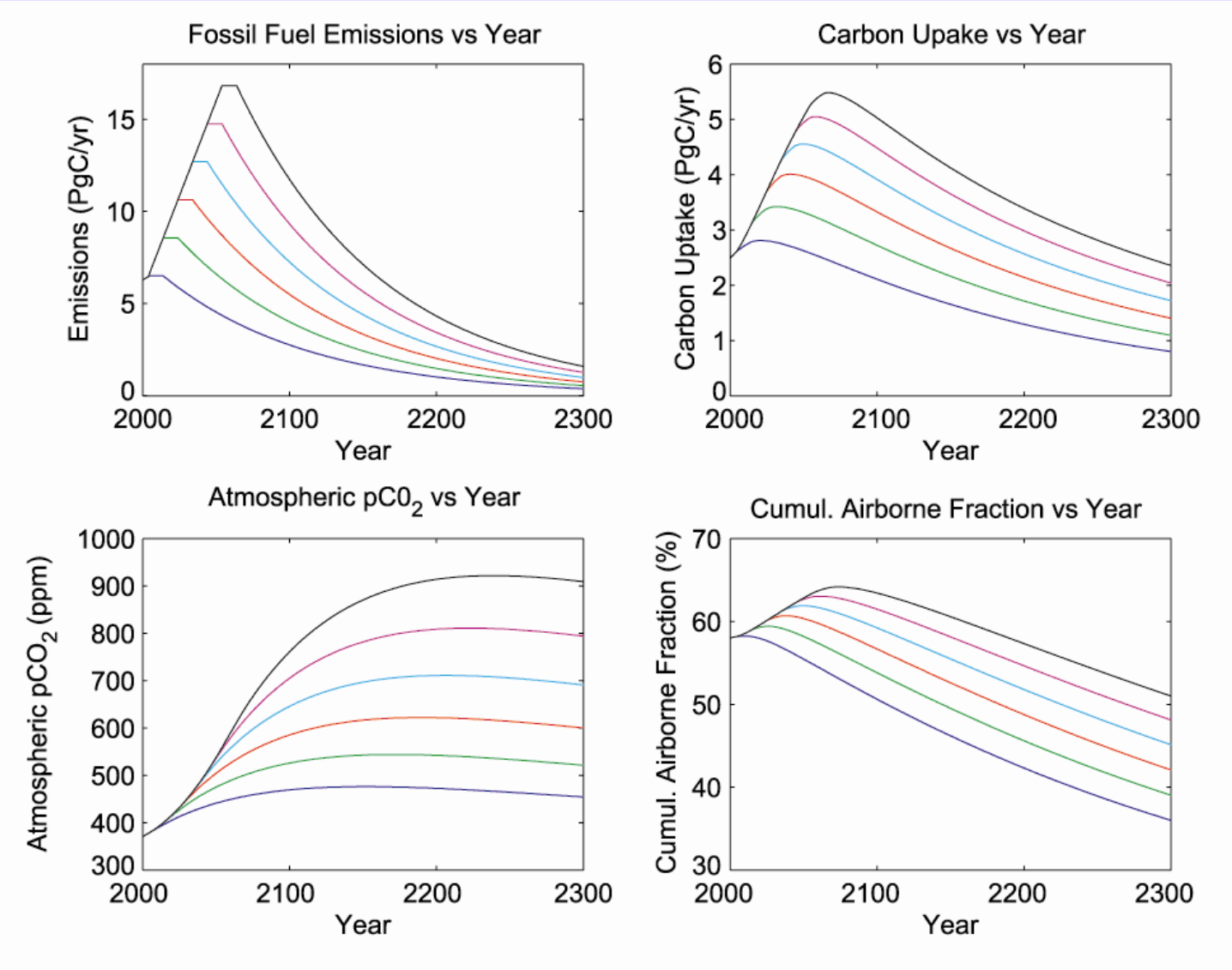
$$\dot{A}(t) = E(t) - F(t)$$

"F" is significant because:

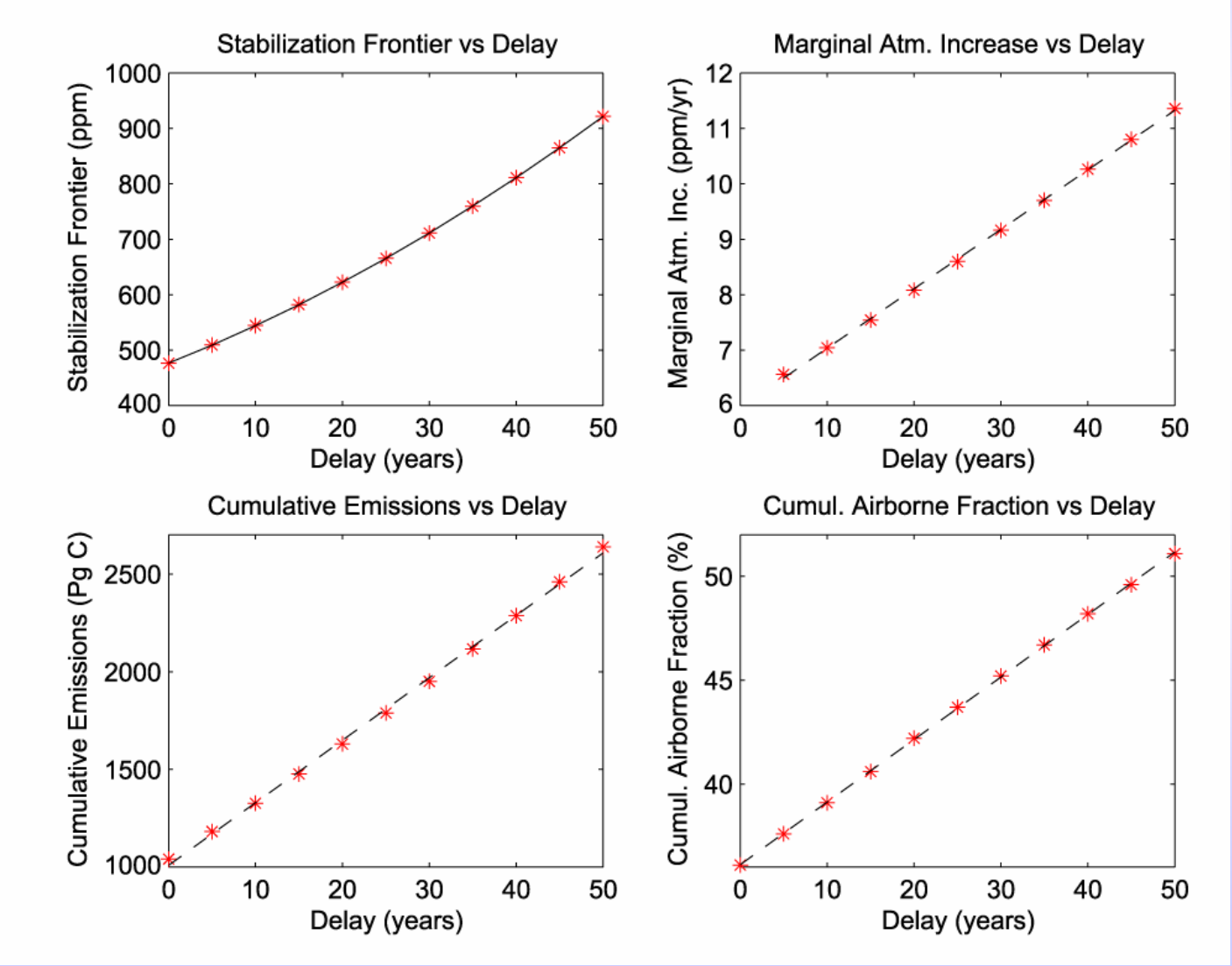
1. CO_2 is soluble in seawater
2. Most CO_2 that enters the ocean is quickly converted into other chemical species
3. Ocean transport facilitates communication between surface and deep ocean



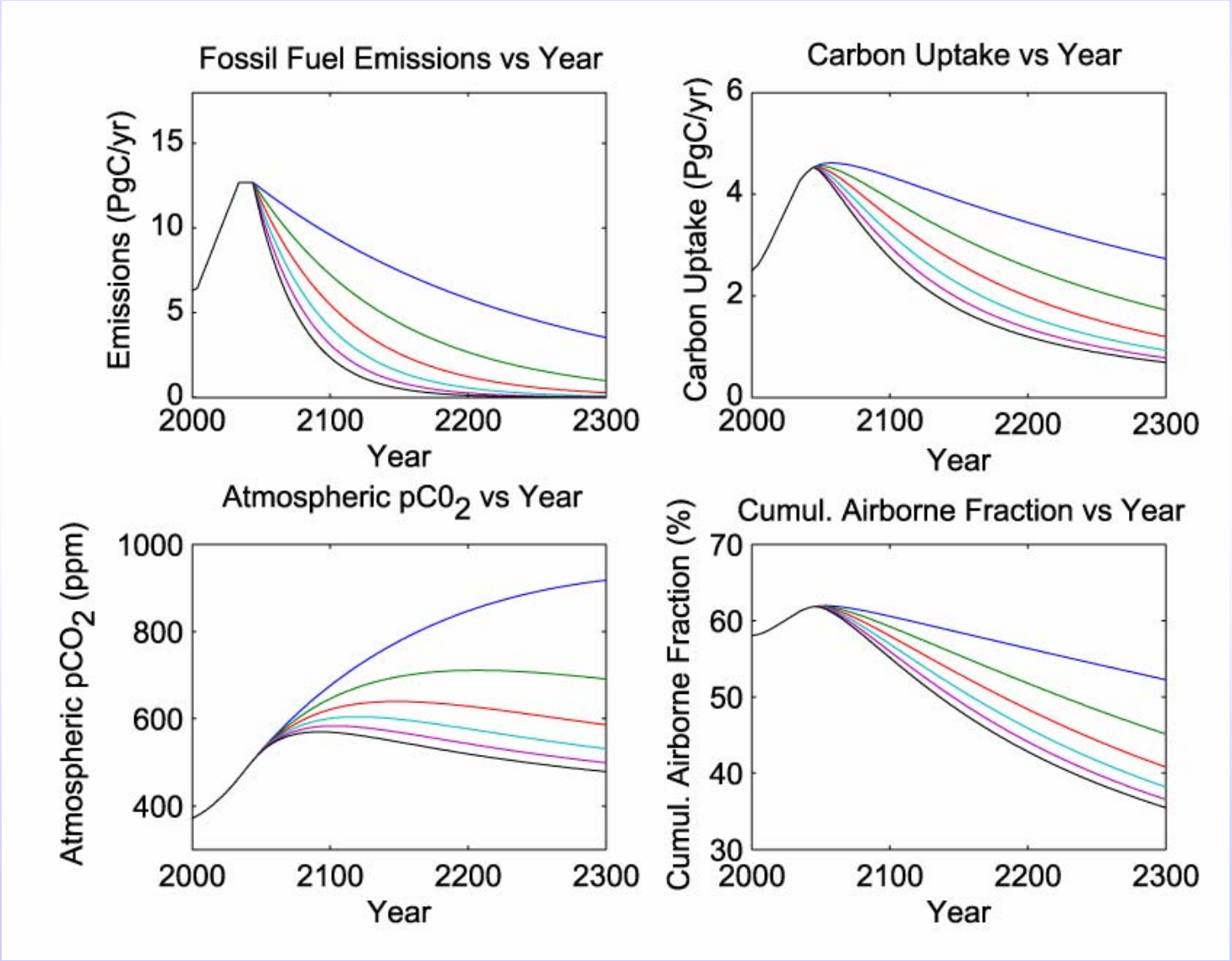
Some Illustrative Scenarios



The Stabilization Frontier



Future Intensification



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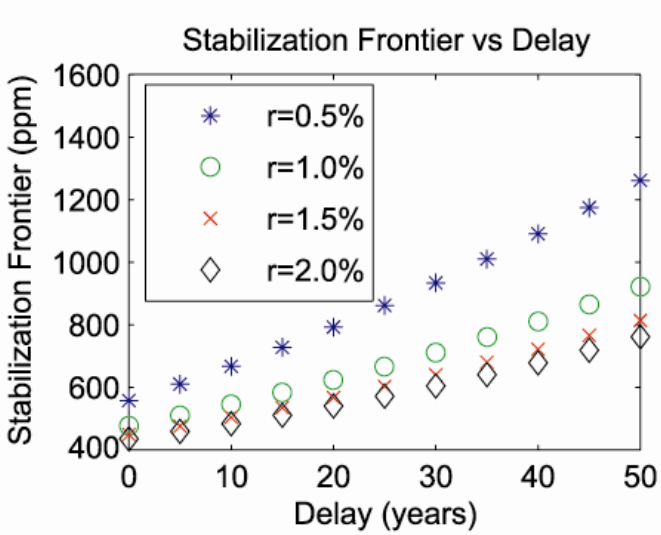
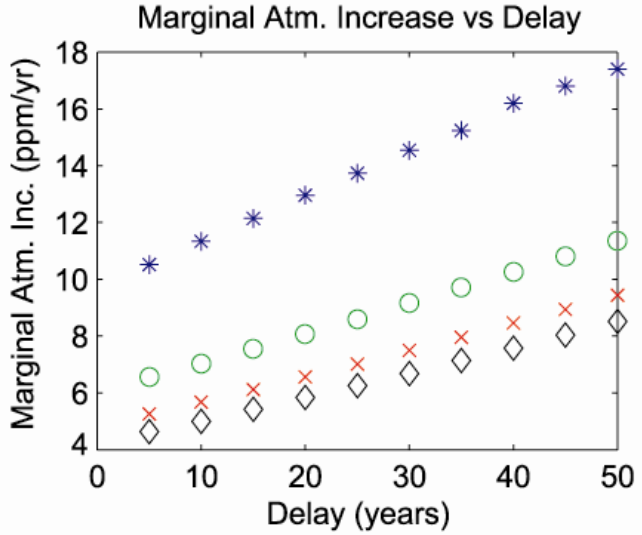
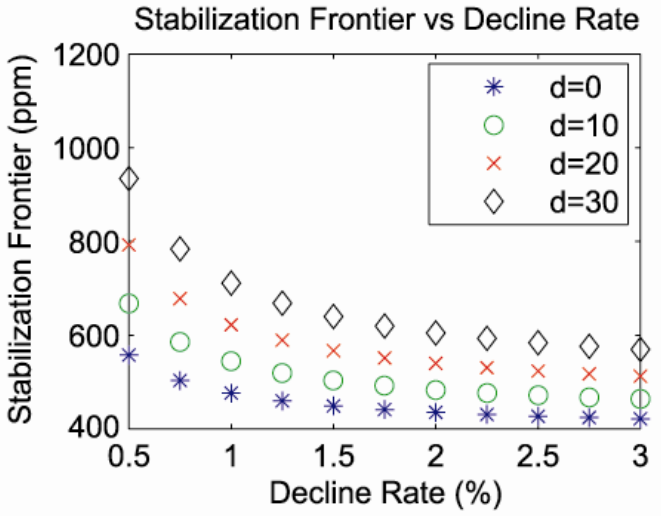
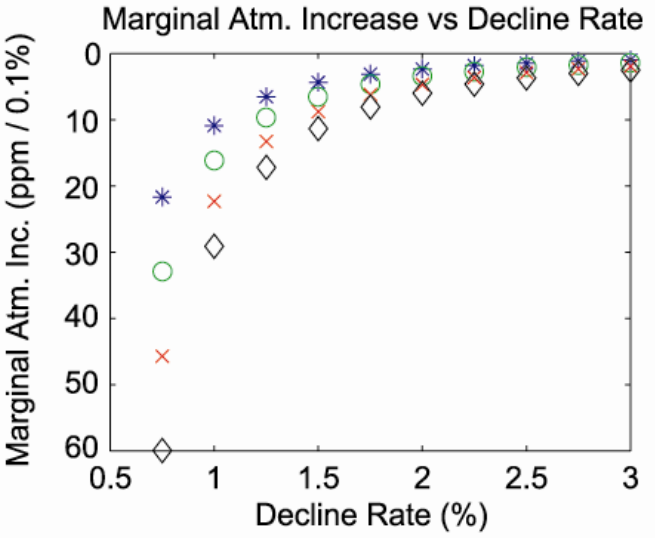
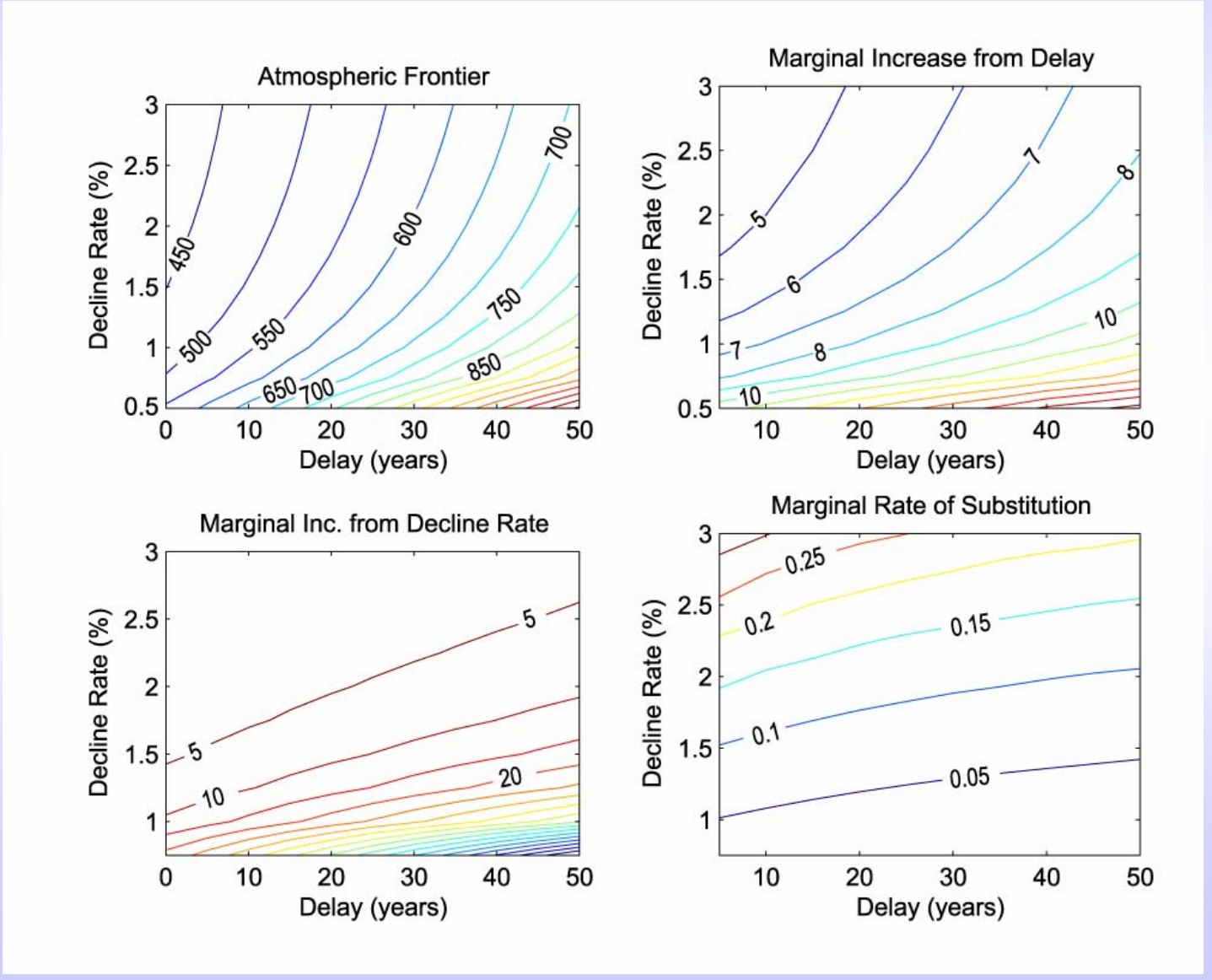




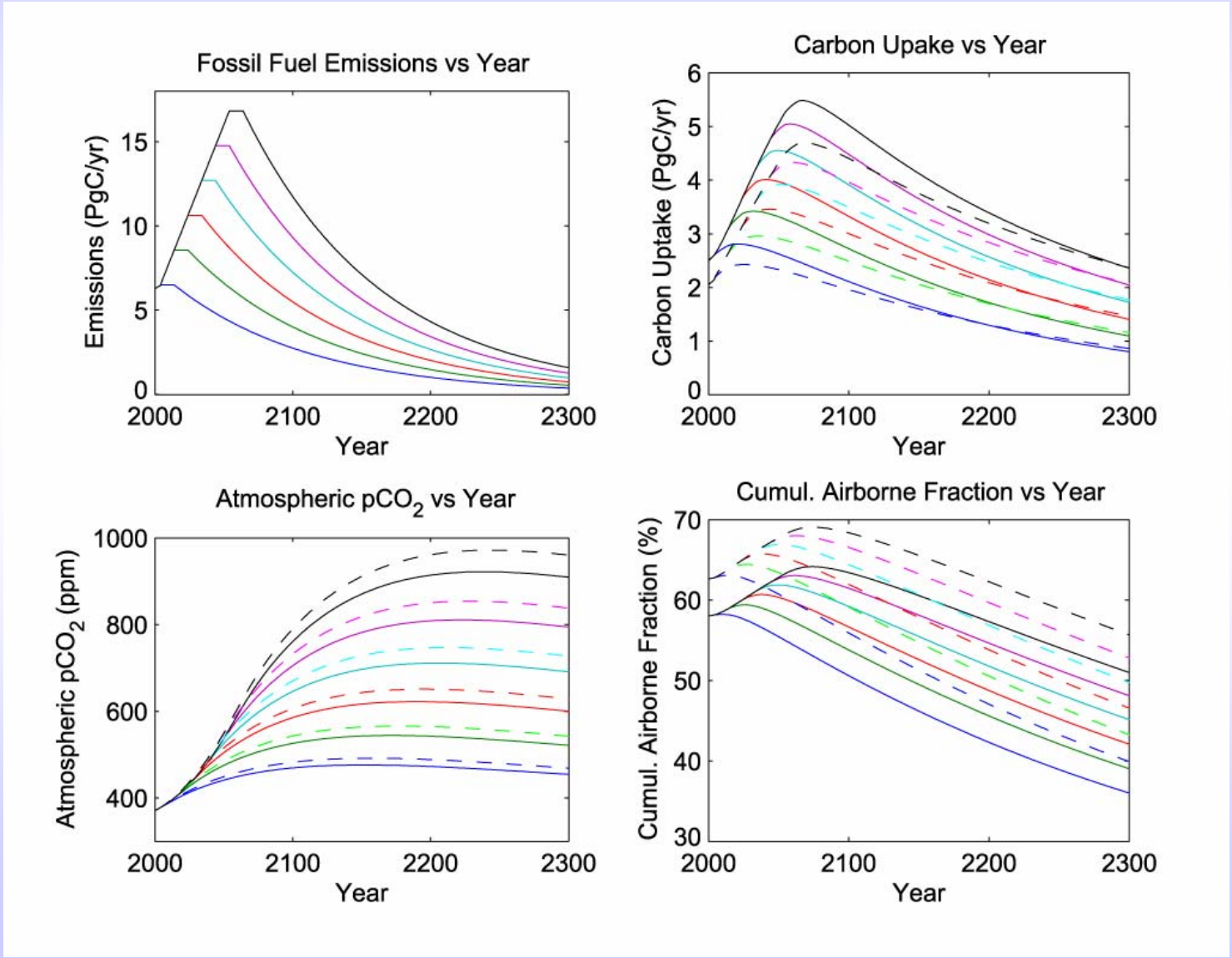




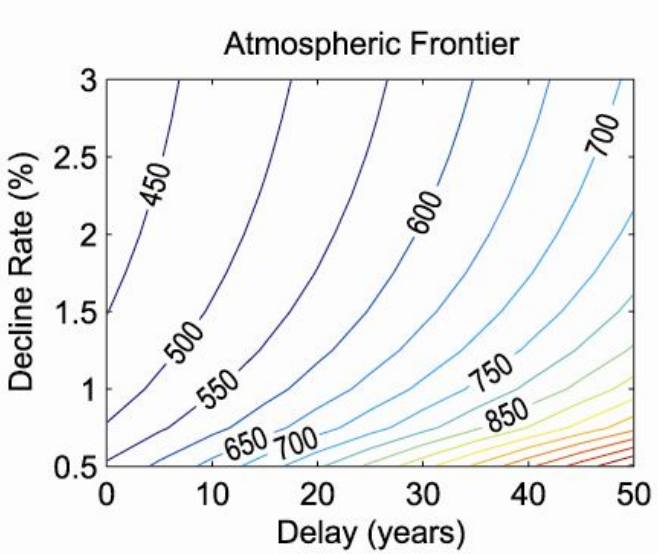
Indifference Curves

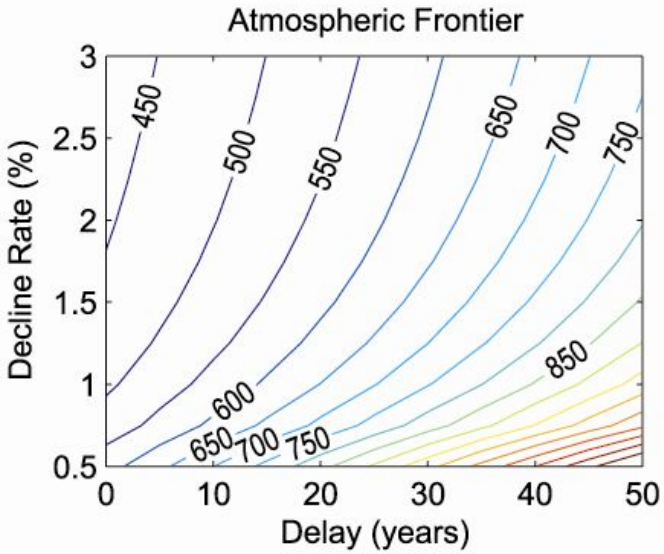


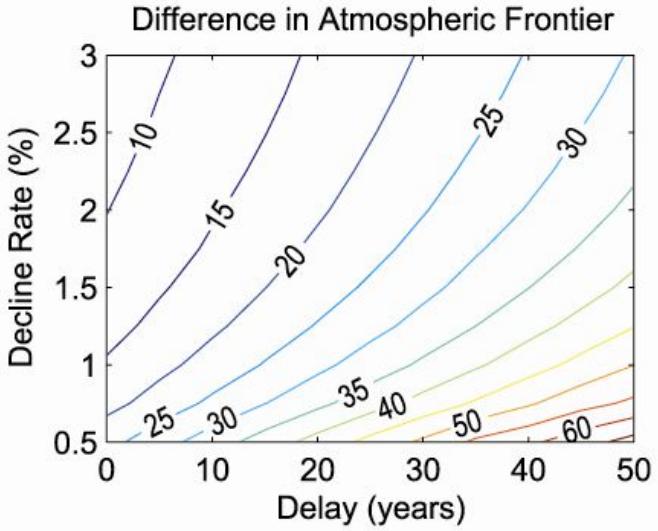
An Alternative World

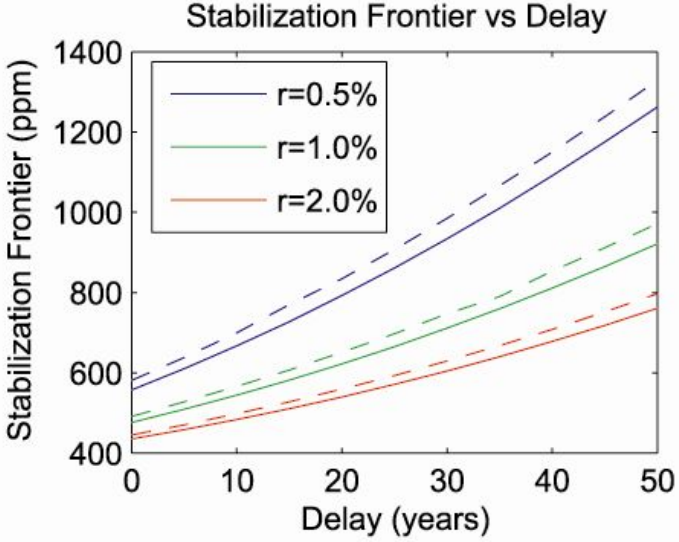


Sensitivity to Carbon Sink









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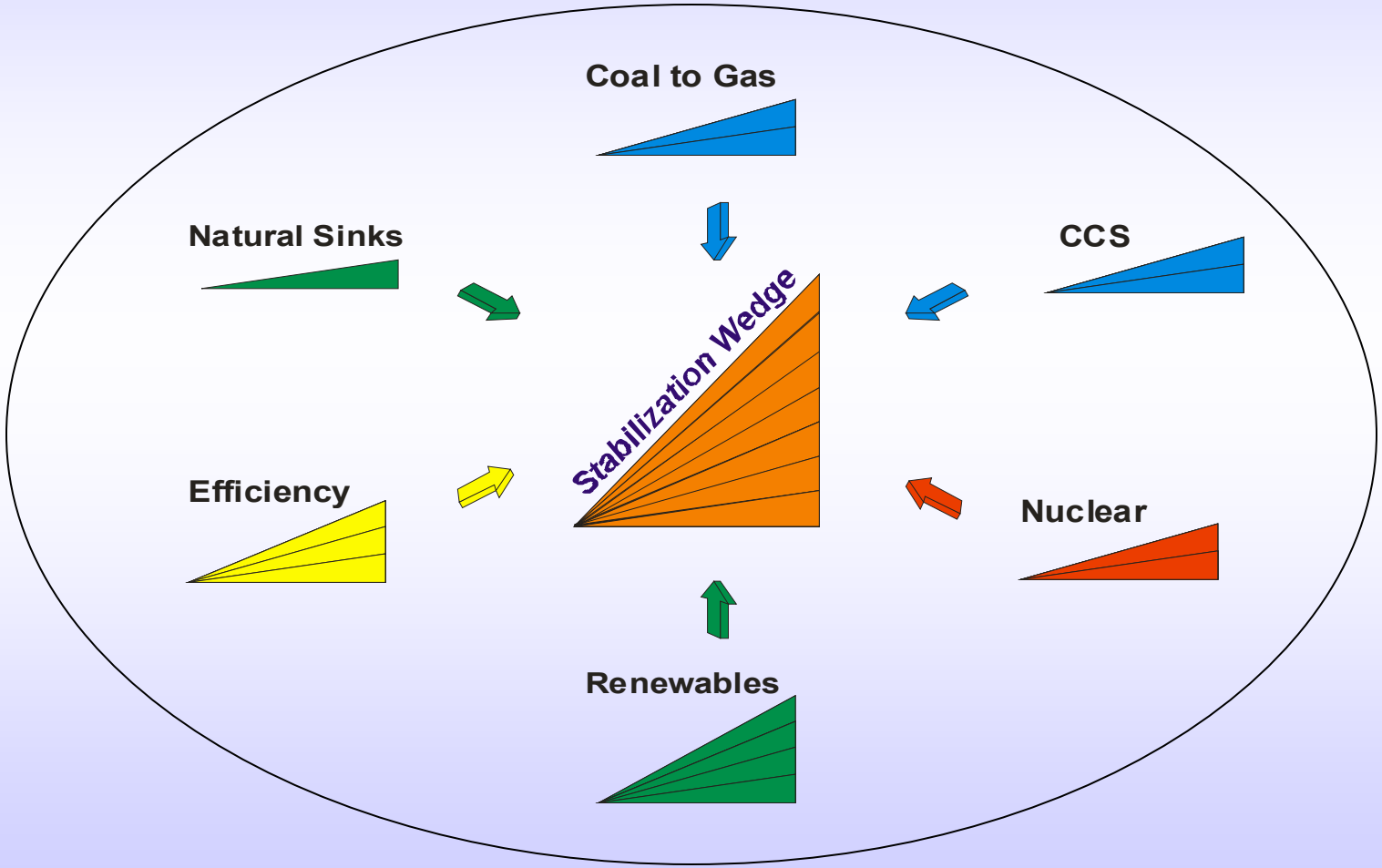
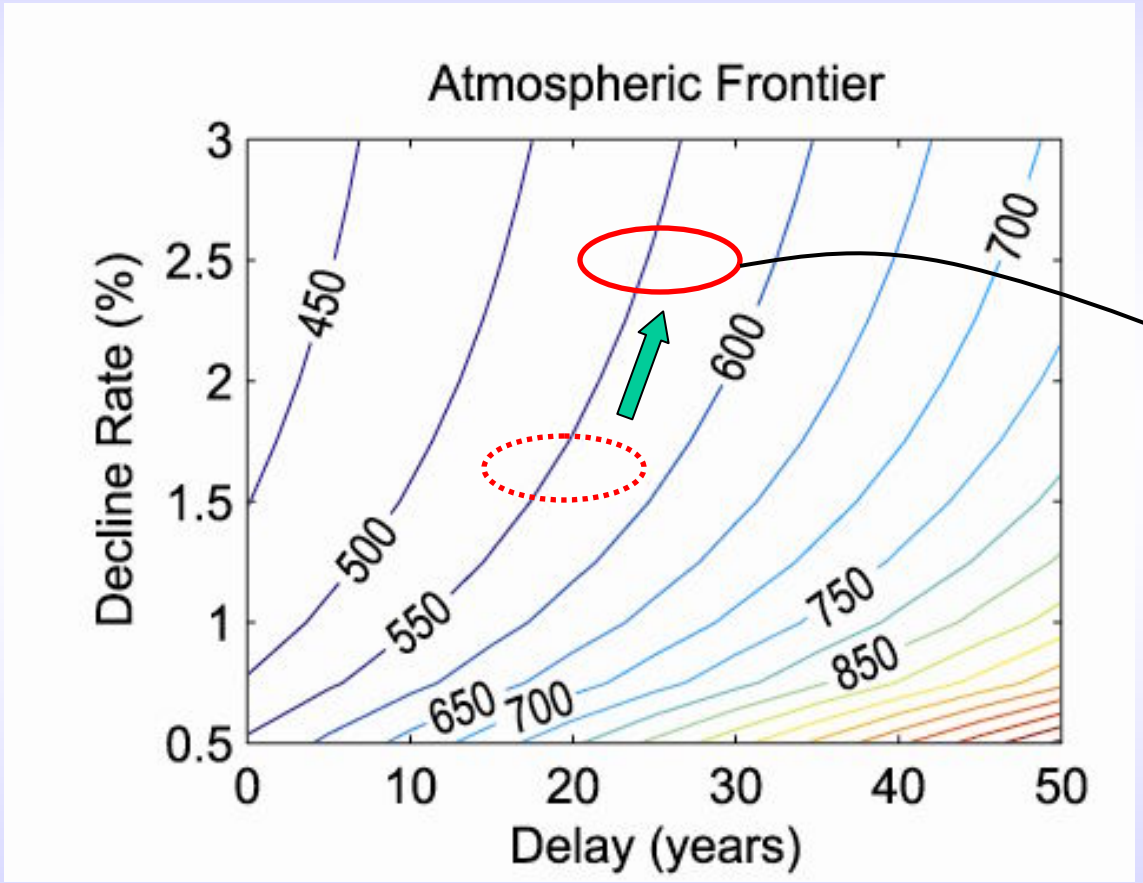
The Stabilization Wedge



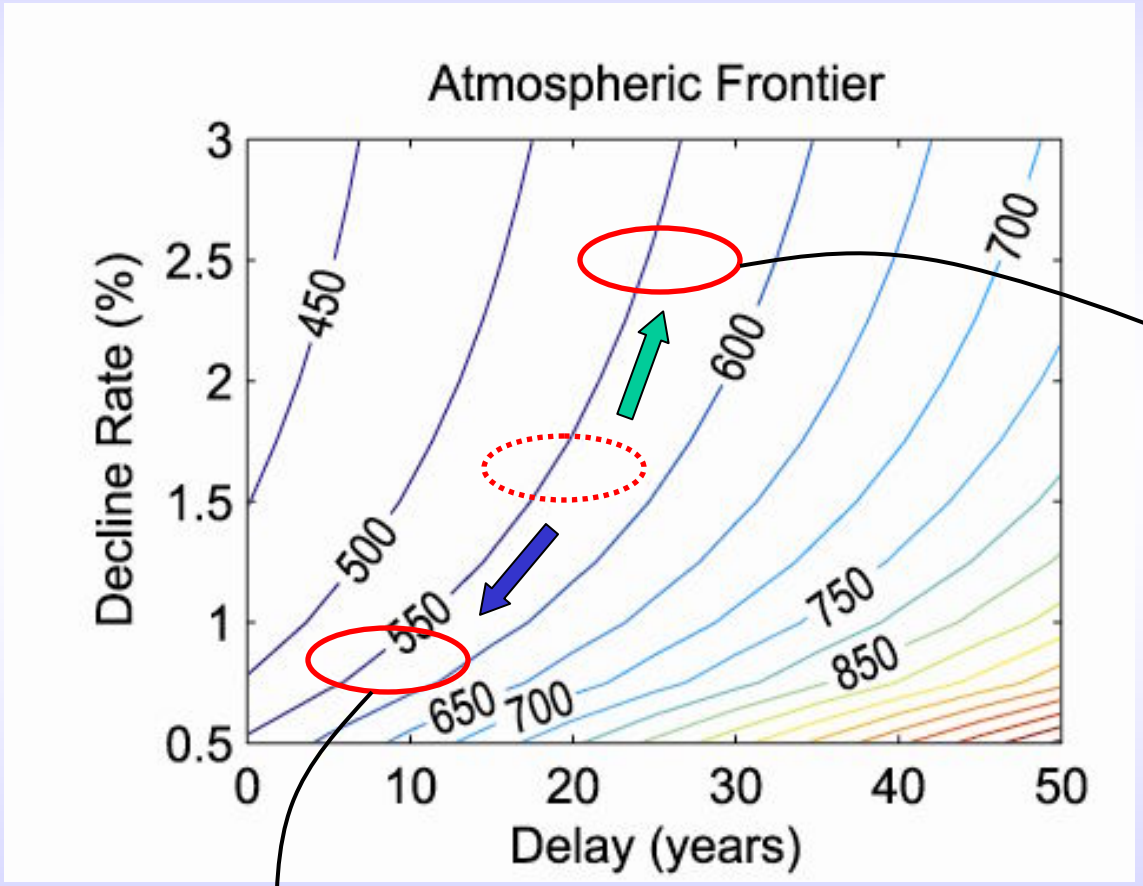
Pacala and Socolow, 2004. Figure courtesy S. Pacala

The Role of CCS?



Technologies that can enhance the magnitude of future mitigation could mitigate present delay

The Role of CCS?



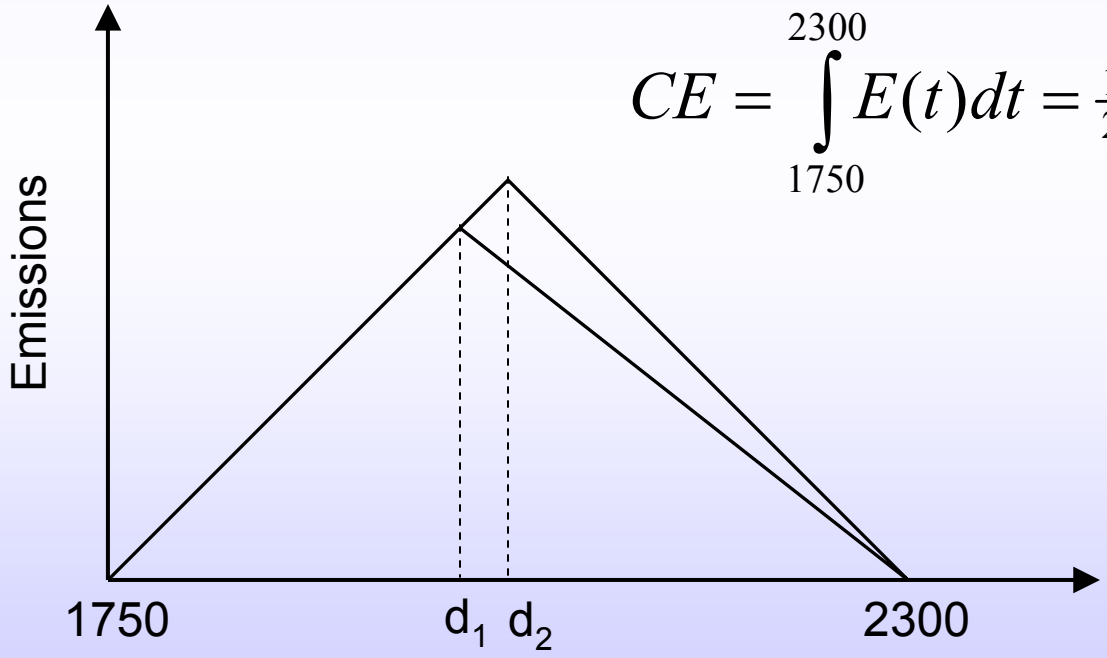
Technologies that can enhance the magnitude of future mitigation could mitigate present delay

Technologies that can be deployed quickly allow us to achieve a given target with less delay

Conclusions

- Current scientific/impacts literature suggests that stabilization below a pre-industrial doubling (~550 ppm) is a reasonable interpretation of Article 2.
- If emissions are constrained to fall at ~1%/yr, then each year of delay ~ 9 ppm → delays of more than a decade preclude stabilization below a doubling.
- If emissions decline rate is free to vary, then postponement can be compensated by increases in the future intensity of mitigation (defines a stabilization "indifference curve").
- Stabilization *target* set by Article 2 (science), while stabilization *path* set by Article 3 (economics).
- Viable CCS technologies open up other possibilities along the frontier.
- Results are robust to carbon cycle assumptions.

Cumulative Emissions



$$CE = \int_{1750}^{2300} E(t)dt = \tfrac{1}{2} b \cdot h = \tfrac{1}{2} \Delta T \cdot d \sim d$$